

TiO₂ photocatalysis

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It is known that TiO₂ exhibits good photocatalytic properties which could be used in various commercial applications such as water and air purification or photo-induced biodegradation of microbes. TiO₂ occurs in nature in the form of three crystal polymorphs: anatase, brookite and rutile. For photocatalytic applications only anatase and rutile are of interest, however anatase shows greater photocatalytic activity. The ability to carry out photocatalytic reactions arises from TiO₂ band gap. When TiO₂ is irradiated with light of energy equal or higher to its band gap energy, an electron is promoted from the valence band to the conduction band leaving behind a positive hole. These photogenerated charge carriers can be trapped by surface adsorbed molecules, form strong radicals and oxidize organic compounds. However, a drawback in TiO₂ photocatalysis is that it absorbs mainly ultraviolet light. Therefore many efforts are made to prepare visible light-active TiO₂.

Photocatalytic activity of titania (TiO₂) depends on its crystal phase, crystallinity, particle size and/or specific surface area. High crystalline TiO₂ exhibits higher photocatalytic activity due to less bulk defects, which represent recombination centers for photogenerated charge carriers. On the other hand, high crystalline particles are usually large and the photogenerated electrons and holes undergo volume recombination before they can be trapped by surface adsorbed molecules and form radicals which are very important for photocatalytic activity. Powders consisting of small particles exhibit high specific surface area and offer more active sites for photocatalytic reactions [1], [2].

According to literature data, anatase with high specific surface area can be prepared by block copolymer templating sol-gel process. In order to achieve high crystalline anatase thermal treatment at higher temperature (300°-600°C) must be performed which leads to the collapse of organic templated structure supporting the TiO₂ framework and causes decrease of specific surface area. Thermal stability of TiO₂ can be improved by using phosphoric acid as a catalyst. The incorporation of phosphorus can stabilize TiO₂ framework by inhibiting particle growth and increase the specific surface area [3], [4].

It was reported that crystalline anatase can be prepared at low temperatures (90°C) by hydrothermal synthesis. At elevated temperature and pressure the conversion of amorphous TiO₂ into crystalline TiO₂ occurs [5].

Anatase powders with high crystallinity and high specific surface area were prepared by combined sol-gel and solvothermal synthesis followed by thermal treatment. Triblock copolymer P123 was used as a template and phosphoric acid (H₃PO₄) as a framework stabilizer. We can conclude that the use of P123 and H₃PO₄ during the applied synthesis route leads to formation of crystalline anatase with high specific surface area (up to 296 m²/g) even after thermal treatment at high temperatures (at 500°C, up to 176 m²/g and at 600°C, up to 136 m²/g).

References:

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